Original Article

Prevalence of Congenital Anomalies of the Inferior Vena Cava: CT Assessment in Thai Patients

Anoma Sanpatchayapong MD[1], Suwara Issaragrisil MD[1]

[1] Division of Diagnostic Radiology, Department of Radiology, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand

Objective: To determine the prevalence of inferior vena cava (IVC) anomalies in Thai patients who underwent contrast-enhanced computed tomography (CT) of the abdomen.

Materials and Methods: Two radiologists retrospectively and independently reviewed the contrast-enhanced abdominal CT examinations in 1,429 Thai patients between August 1, 2018 and January 25, 2019 who met the inclusion criteria. Patients were included, if (a) their CT showed well visualized IVC, renal veins, and right ureter that were not obliterated by tumor, cyst, fluid collection, or intraperitoneal free fluid, (b) they had not undergone previous abdominal surgery that altered anatomical configuration of the IVC, renal veins, and right ureter. The presence of all IVC anomalies were recorded.

Results: Among the 1,429 studied patients, 678 were male (47.4%) and 751 were female (52.6%). The prevalence of IVC anomalies was 3.5%. Five types of IVC anomalies were presented. The most common was circumaortic left renal vein in 24 patients or 48.0% of all IVC anomalies and 1.7% of the study population, followed by retroaortic left renal vein in 15 patients or 30.0 % of all IVC anomalies and 1.0% of the study population. Other IVC anomalies included double IVC, left IVC, and retrocaval ureter at 0.5%, 0.2%, and 0.1% of the study population, respectively.

Conclusion: The prevalence of IVC anomalies in the present study differed from the previous studies conducted in other countries, which may be attributable to differences in race and ethnicity. Awareness of these anomalies is essential when evaluating routine CT examinations in asymptomatic patients. Their presence should be carefully noted in radiology reports to avoid anomaly-related complications.

Keywords: Prevalence; IVC anomalies; Circumaortic left renal vein; Retroaortic left renal vein; Double IVC; Left IVC; Retrocaval ureter

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Congenital anomaly of the inferior vena cava (IVC) was first described in 1793 by Abernethy in a 10-month-old female with dextrocardia and a congenital mesocaval shunt and azygos continuation of the IVC[1]. Huntington and McLure studied IVC development in domestic cats and found up to 14 anatomical anomalies of the infrarenal IVC, 11 of the 14 can also be found in humans[2].

Most IVC anomalies cause no symptoms and are found incidentally on imaging studies[3-5]. However, some are clinically significant. These can be misdiagnosed as paraaortic adenopathy[6]. They cause difficulty in placing an infrarenal filter using the transjugular technique[7] and are associated with high risk of spontaneous venous thromboembolism of the iliac vein[8]. Retrocaval ureter may cause upper ureteric obstruction because of upper ureter entrapment by the IVC[9]. Furthermore, IVC anomalies can cause poor abdominal surgical outcomes such as failure of renal transplantation and massive intraoperative blood loss[10,11].

Abdominal computed tomography (CT) is widely used to evaluate patients with abdominal symptoms. CT examinations with intravenous contrast medium can accurately evaluate IVC structure and detect congenital anomalies. The present study aimed to investigate the prevalence of IVC anomalies in patients that underwent abdominal CT to gain a better understanding of these anomalies and convey awareness of them to clinicians and radiologists.

Materials and Methods

The present study was a retrospective descriptive study. The study was approved by the Institutional Review Board Office, Research Affairs, Navamindradhiraj University (IRB No. 147/61).

Correspondence to:

Sanpatchayapong A,

Division of Diagnostic Radiology, Department of radiology, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok 10300, Thailand.

Phone: +66-2-2443000 ext. 3245

Email: anoma@nmu.ac.th

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The authors included Thai patients that underwent contrast-enhanced multidetector (MD) CT of the abdomen, which included the lower part of the thorax and lower abdomen, covering the aortic bifurcation between August 1, 2018 and January 25, 2019. The patients were included, if (a) their CT showed well visualized IVC, renal veins, and right ureter which were not obliterated by tumor, cyst, fluid collection, or intraperitoneal free fluid, (b) they had not undergone previous abdominal surgery that altered anatomical configuration of the IVC, renal veins, and right ureter. According to a previous study, the prevalence of circumaortic left renal vein was 6.3%[12] with type I=0.05 and allowable error=1.26. The estimated number of patients was 1,429 cases[13].

CT scans were retrospectively and independently reviewed on the image archiving and communication system workstation by the two blinded radiologists who recorded the presence of various IVC anomalies. These included left IVC, double IVC, absence of IVC, circumaortic left renal vein, retroaortic left renal vein, retrocaval ureter, hemiazygos continuation of the IVC, and azygos continuation of the IVC[4,5,10]. Intraobserver reliability was evaluated. Interobserver reliability evaluation showed 100% agreement (Cohen's kappa 1.000).

The CT was performed with 64 detector and 128 detector CT scanners (Brilliance; Philips Medical Systems, Amsterdam, the Netherlands). All patients received intravenous contrast medium at an appropriate dose and rate according to age, weight, quality of the vein, and type of CT examination. Images were reconstructed at 3 mm section thickness in the axial and coronal planes.

Data analysis was performed with PASW Statistics, version 18.0 (SPSS Inc., Chicago, IL, USA). Prevalence of IVC anomalies were presented as numbers with percentage. Chi-square test and Fisher's exact test were used to compare the difference in prevalence of IVC anomalies between male and female groups.

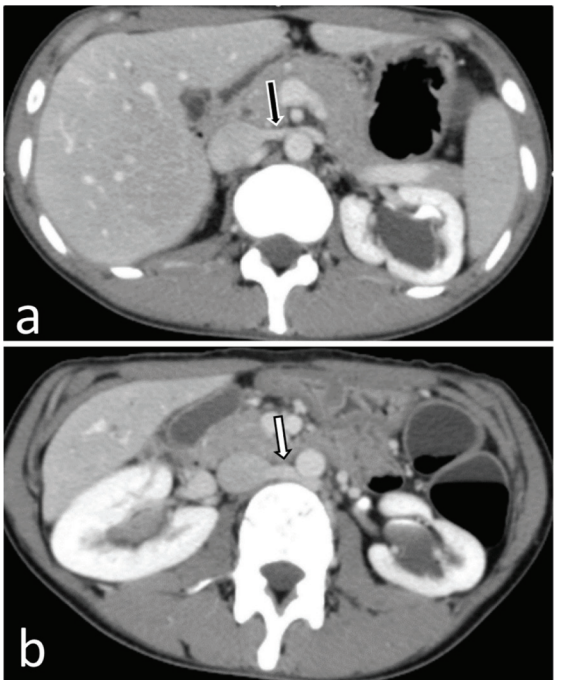

Figure 1. Circumaortic left renal vein. (a, b) CT sections are presented from cranial to caudal and show two left renal veins, with the superior left renal vein (black arrow) crossing anterior to the aorta and the inferior left renal vein (white arrow) crossing posterior to the aorta.

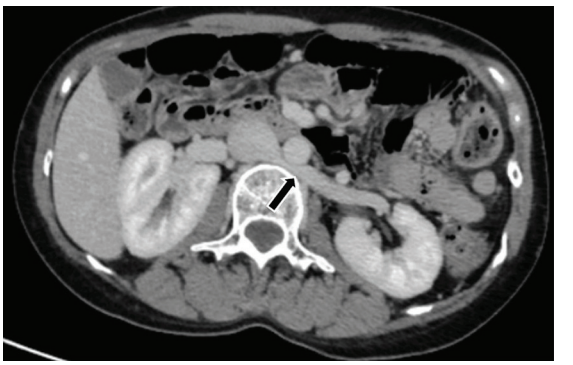

Figure 2. Retroaortic left renal vein. CT shows a single left renal vein (black arrow) that crosses posterior to the aorta.

Results

Among the 1,429 study patients, 678 were male (47.4%) and 751 were female (52.6%). Mean age was 58.3 years with a range of 4 to 100. IVC anomalies were presented in 50 patients (3.5%). Among the five types detected, the most common anomaly was circumaortic left renal vein, found in 24 patients or 48.0% of all IVC anomalies and 1.7% of the study population (Figure 1), followed by retroaortic left renal vein, found in 15 patients or 30.0% of all IVC anomalies and 1.0% of the study population (Figure 2). Other IVC anomalies included double IVC (Figure 3), left IVC (Figure 4), and retrocaval ureter (Figure 5). These anomalies were presented in 0.5%, 0.2%, and 0.1% of the study population, respectively (Table 1).

Overall, IVC anomalies were found in 23 males and 27 females. Circumaortic left renal vein was found in 10 males and 14 females, retroaortic left renal vein in six males and nine females, double IVC in four males and three females, left IVC in two males and

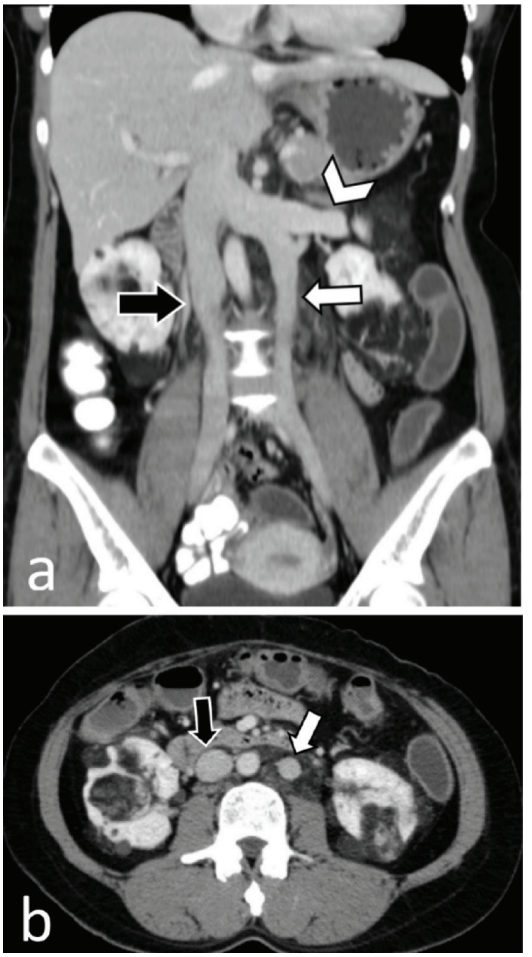

Figure 3. Double IVC with multiple angiomyolipomas. (a, b) Coronal and axial CT images show the right and left IVC. The left IVC (white arrow) drains into left renal vein (arrowhead), then joins the right IVC (black arrow).

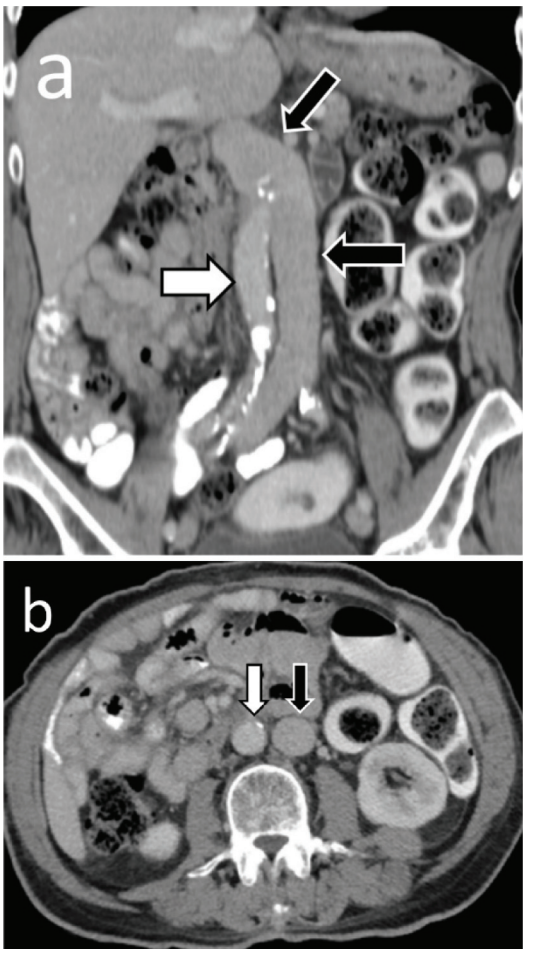

Figure 4. Left IVC. (a, b) Coronal and axial CT images show the left IVC. The left IVC (black arrow) is located at the left side of the aorta (white arrow) and then courses anterior to the aorta to become the normal (right sided) suprarenal IVC.

Table 1. Prevalence of IVC anomalies

IVC anomaly	All IVC anomaly (%)	All studied patients (%)
All types of IVC anomalies (n=50)	100.0	3.5
Circumaortic left renal vein (n=24)	48.0	1.7
Retroaortic left renal vein (n=15)	30.0	1.0
Double IVC (n=7)	14.0	0.5
Left IVC (n=3)	6.0	0.2
Retrocaval ureter (n=1)	2.0	0.1

IVC=inferior vena cava

Table 2. Sex and IVC anomalies

IVC anomaly	Male	Female	p-value
Overall	23	27	0.886
Circumaortic left renal vein	10	14	0.682
Retroaortic left renal vein	6	9	0.613
Double IVC	4	3	0.714
Left IVC	2	1	0.607
Retrocaval ureter	1	0	0.474

IVC=inferior vena cava

one female, and retrocaval ureter in one male (Table 2). In the patient with retrocaval ureter, the CT showed right hydronephrosis and proximal hydroureter consistent with upper urinary tract obstruction due to retrocaval ureter; this patient underwent CT because of hematuria with pain. The authors did not find the hemiazygos continuation of the IVC, the azygos continuation of the IVC, or absent IVC. The patients with circumaortic left renal vein and retroaortic left

Table 3. Reported prevalence rates of various IVC anomalies

IVC anomaly	The present study	Trigaux et al.[12]	Shabban[14]	Koc et al.[15]	Arslan et al.[16]	Reed et al.[17]
Number of patients	1,429	1,014	1,144	1,120	1,125	433
Overall anomalies (%)	3.5	10.4	9.9	10.7	NA	NA
Circumaortic left renal vein (%)	1.7	6.3	5.1	5.5	NA	4.4
Retroaortic left renal vein (%)	1.0	3.7	4.0	4.6	1.7	1.8
Double IVC (%)	0.5	0.3	0.2	0.2	NA	NA
Left IVC (%)	0.2	0.0	0.3	0.1	NA	NA
Retrocaval ureter (%)	0.1	0.0	0.3	0.1	NA	NA
Hemiazygos continuation of the IVC (%)	0.0	NA	NA	0.1	NA	NA
Azygos continuation of the IVC (%)	0.0	0.1	NA	0.1	NA	NA
Absent IVC (%)	0.0	NA	NA	NA	NA	NA

IVC=inferior vena cava; NA=not available

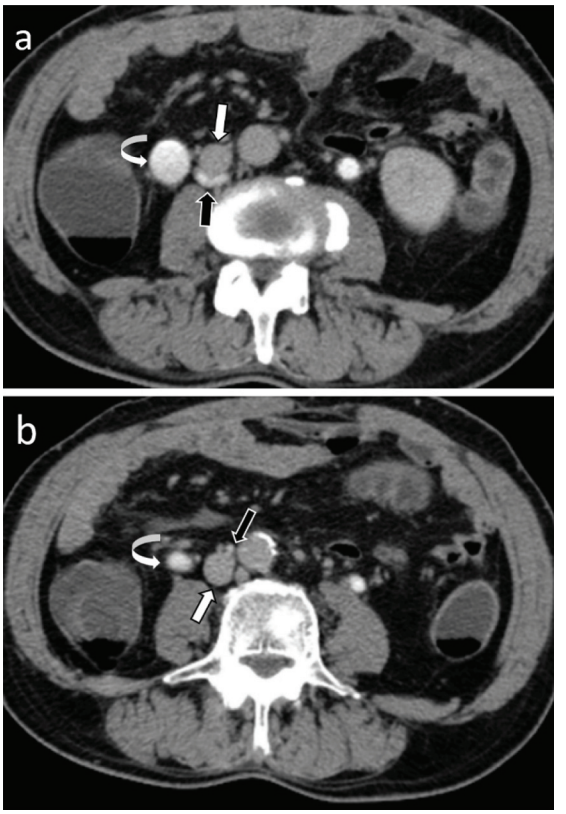

Figure 5. Retrocaval ureter. (a, b) Excretory phase CT sections are presented from cranial to caudal and show the retrocaval ureter (black arrow), which crosses posterior to the IVC (white arrow). The upper ureter is dilated (curved arrow).

renal vein showed no imaging evidence of renal vein thrombosis.

Discussion

The present study examined the prevalence of IVC anomalies in 1,429 patients that underwent CT examination, which is the largest prevalence study to date, to the authors' knowledge[12,14-17]. Such a large sample size should indicate that the present study findings are close to the true prevalence rates. The prevalence rates of IVC anomalies overall, circumaortic left renal vein, retroaortic left renal vein, double IVC, left IVC, and retrocaval ureter in the present study were 3.5%, 1.7%, 1.0%, 0.5%, 0.2%, and 0.1%, respectively. Hemiazygos continuation of the IVC, azygos continuation of the IVC, and absent IVC were not found. No significant gender difference in prevalence of circumaortic left renal vein, retroaortic left renal vein, double IVC, left IVC, and retrocaval ureter were detected in the present study.

Compared to the previous studies, the present study findings have noteworthy similarities and differences (Table 3). The two most common anomalies in the present study were circumaortic left renal vein and retroaortic left renal vein, similar to Trigaux et al[12], Shaaban[14], and Koc et al[15]. However, the prevalence rates of these two in their studies was much higher, while the prevalence of the double IVC was lower. Although, the authors did not find hemiazygos continuation of the IVC or azygos continuation of the IVC, Trigaux et al[12] and Koc et al[15] found a prevalence of 0.1%. The authors believe that the prevalence differences between studies may be caused by differences in race and ethnicity of the study populations. The present study focused on Thai patients, while the studies of Trigaux et al[12], Shaaban[14], and Koc et al[15] were conducted in Belgium, Egypt, and Turkey, respectively.

IVC anomalies can be of clinical significance. The present study patient with a retrocaval ureter

presented with hematuria and pain and exhibited right hydronephrosis and right proximal hydroureter on CT. These symptoms had also been reported by Abrahamx et al[9] and Gonzalez et al[18] in pediatric cases of retrocaval ureter. Washecka et al[19] suggested that retroaortic left renal vein is prone to thrombosed because of its course locate between the aorta and spine. However, the retroaortic left renal veins in the present study showed no evidence of left renal vein thrombosis. Double IVC, left IVC, and retroaortic left renal vein can be mistaken as a retroperitoneal mass or paravertebral lymph node enlargement on radiography and CT[6,20-22]. Unaware of the retroaortic renal vein in abdominal vascular surgical procedures involving the aorta and renal and superior mesenteric arteries can result in retroaortic renal vein laceration and serious bleeding[23]. Strauss et al[11] recommended that pelvic surgeons performing abdominal lymphadenectomy evaluate each patient for the presence of double IVC to avoid unnecessary intraoperative blood loss from left IVC injury. Failure of renal transplantation has been reported in patients with absent IVC and bilateral iliac veins[10]. Knowing that a double IVC anomaly was presented in patients with iliac vein thrombosis and pulmonary embolism is important to avoid IVC filter placement in only one IVC, which causes inadequate treatment[24]. Furthermore, patients with double IVC can experience painful scrotal swelling following laparoscopic living donor nephrectomy[25].

There are limitations to be considered in the present study as the authors could not determine the true prevalence of the hemiazygos continuation of the IVC, azygos continuation of the IVC, and absence of the IVC due to their rarity. Future large prevalence studies are warranted to further investigate.

Conclusion

The prevalence rates of IVC anomalies in overall, circumaortic left renal vein, retroaortic left renal vein, double IVC, left IVC, and retrocaval ureter in the present study were 3.5%, 1.7%, 1.0%, 0.5%, 0.2%, and 0.1%, respectively. Awareness of these anomalies is essential when evaluating routine MDCT examinations in asymptomatic patients. Their presence should be carefully noted in radiology reports to avoid anomaly-related complications.

What is already known on this topic?

Congenital anomaly of the IVC was first described more than 200 years ago. Most IVC anomalies cause no symptoms and are found incidentally on imaging studies. These can be misdiagnosed as paraaortic adenopathy and be associated with high risk of spontaneous venous thromboembolism of the iliac vein. Still, there was a limitation in a Thai population for the prevalence of congenital anomaly of IVC.

What this study adds?

The prevalence of IVC anomalies among Thai people in one academic center were 3.5% of the study population. Among the five types detected, the most common anomaly was circumaortic left renal vein, found in 48.0% of all IVC anomalies and 1.7% of the study population.

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Conflicts of interest

The authors declare no conflict of interest.

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